STATEMENT TESTIMONY OF

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Introduction

Good morning Chairman Smith, Ranking Member Miller, members of the Committee, I am pleased to be here on behalf of the nearly 100,000 Department of Defense Science and Technology (S&T) men and women who strive to discover, develop, mature, and field the best possible technologies at an affordable price for the soldiers, sailors, airmen, marines, and civilians deployed in defense of our nation and national objectives. To meet this challenge requires us to develop the best capabilities we can from our DoD laboratories. It also requires us to partner with all elements of the national infrastructure developing advanced technologies—academia, industry, small business, and other federal agencies. Finally, delivering the best possible technology to our deployed forces, and those forces allied with us, requires us to join with partner nations when possible. Taken together, developing and delivering the best possible technology to our forces is a complex and multi-faceted effort. It is my distinct honor today to provide information to show that we are making progress toward addressing this challenge on a number of fronts.

This is an exciting time to be in DoD S&T, a time with a great deal of on-going change of focus. For the third straight year, we submitted a President's Budget Request for Science and Technology that conveys substantial change driven by the continuing shift in national security priorities to meet the requirements of fighting our current irregular military engagement. Counter-insurgency warfare and the battle against terrorists, requires the DoD to continue to expand our capabilities in diverse areas such as persistent surveillance, protection technologies, cultural and social modeling, and other non-kinetic capabilities. At the same time, the Department needs to maintain adequate conventional operational capabilities. In total, we have moved over $6 billion of S&T investment over the last three President's Budget Requests[1] to address new mission areas.

This year's budget submission was guided by four strategic principles[2]—the first stated by Secretary of Defense Gates in his FY 2009 Budget posture hearing; the other three were highlighted in Secretary Gates' April 6, 2009 speech that laid out the budget priorities for the Department of Defense.

In a February 2008, during the FY 2009 Defense posture statement, Secretary Gates specifically highlighted the need to expand basic research when he said:

> "As changes in this threat environment create strategic challenges—irregular warfare, weapons of mass destruction, disruptive technologies—this request places greater emphasis on basic research, which in recent years has not kept pace with other parts of the budget."

[1] The $6B estimate represents the planned budget developed through the Future Year's Defense Program—effectively, the planned investment from the present through 2013 to 2015. The actual investment will likely have some modifications, but the planned investment does indicate the priorities of the Department.
[2] Throughout this testimony, we will refer to four strategic principles; these are made up of the FY 2009 priority for basic research and three strategic imperatives from Secretary Gates April 6, 2009 speech.

While Secretary Gates emphasized this strategic imperative last year, the importance also has been highlighted by President Obama, who said, in a major speech at the National Academies of Science on April 27, 2009. In this speech, President Obama said:

> "I believe it is not in our American character to follow – but to lead. And it is time for us to lead once again. I am here today to set this goal: We will devote more than three percent of our GDP for research and development. We will not just meet, but we will exceed the level achieved at the height of the space race, through policies that invest in basic and applied research…"

The three remaining strategic priorities or imperatives were defined by Secretary Gates in his speech of April 6, 2009 outlining the Department's budget priorities. This speech clearly stated these imperatives of the Department, which are:

1. Taking care of our people
2. Developing the capabilities to fight the current and future wars
3. Improving our acquisition capabilities and accountability.

The Department of Defense S&T budget submission we are discussing today addresses all of these priorities and more, building upon our budget request of the past several years, that aligns the S&T investment to Irregular Warfare challenges. We will discuss each of these principles in detail and highlight the recent accomplishments of the S&T program after we provide a macro-scale overview of the Department's S&T budget request.

The Fiscal Year 2010 Defense S&T Budget Request – Macro-scale

The FY 2010 President's Budget Request of $11.649 billion represents a strong Department of Defense continued corporate commitment to investment in S&T. This commitment continues despite a challenging budgetary environment supporting deployed military operations and other growing non-discretionary departmental obligations. Specifically, the FY 2010 request came within 0.5% of maintaining real growth compared to FY 2009. In fact, the S&T program fared well in comparison to many other discretionary accounts. For instance, the RDT&E budget categories of Advanced Component Development and Prototypes, and System Development and Demonstration both encountered over 9% real reductions.

It is perhaps more important to take a look at the recent and long term trend of DoD S&T funding; the combined growth of the DoD S&T budget request from FY 2008 to FY 2010 budget is about 4%, in real terms. From FY 2002 to 2010 the S&T budget has grown nearly 15% above inflation, or a sustained growth of nearly 2% per year. Figure 1 shows the President Budget Request, in constant dollars from 1997 to 2010 – clearly the DoD has increased emphasis on S&T. Even more telling is the long-term view of Defense S&T investment, since 1962 as seen in Figure 2. In fact, in constant dollars, and with the exception of a one year spike in 1992 due to the Technology

Reinvestment Program, the largest seven budget requests have come since 2002, and the FY 2010 request is near the top.

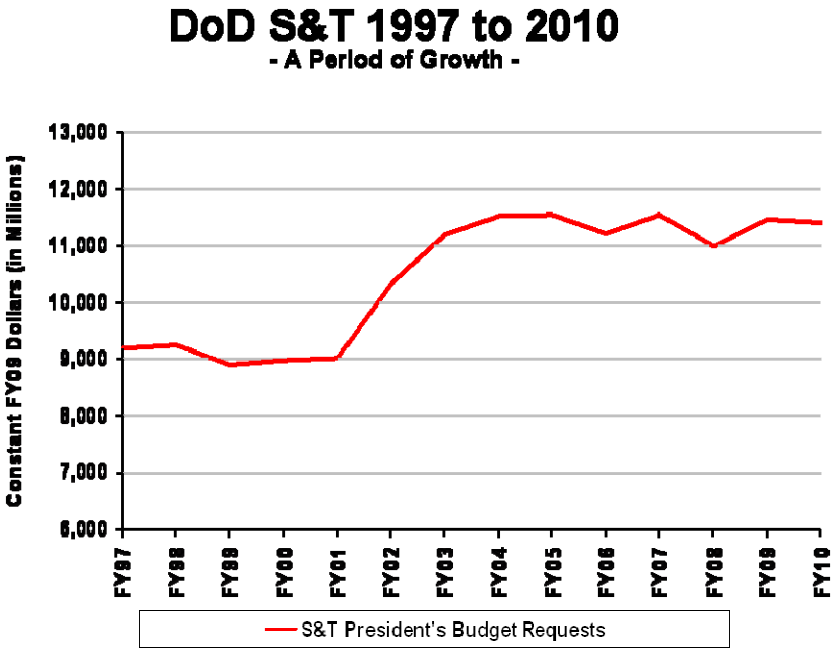

Figure 1

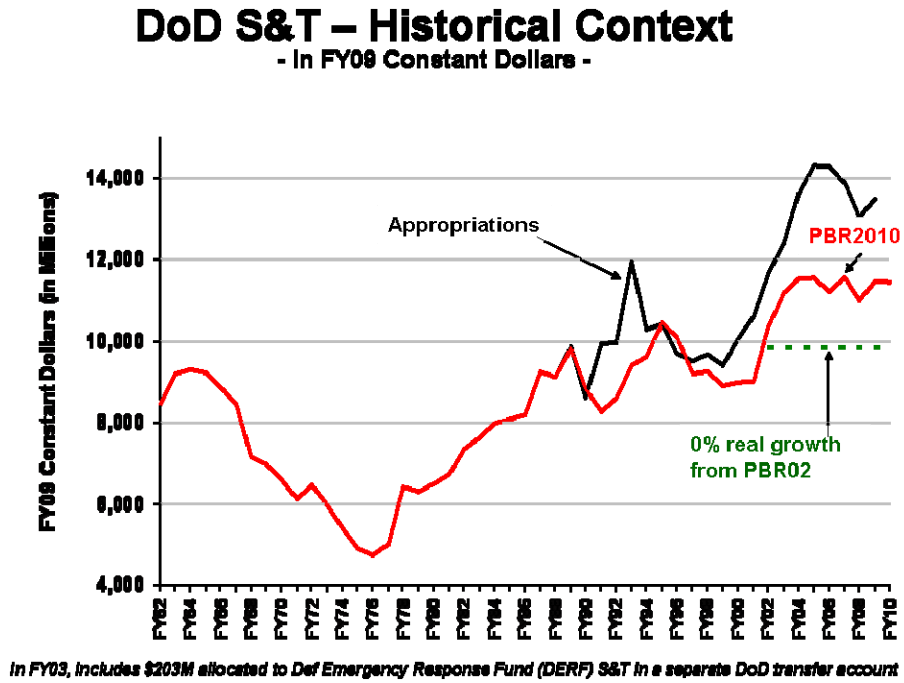

Figure 2

Table 1 shows the specifics of the FY 2010 budget, compared to FY 2009, by budget category.

Comparison of DoD Research and Engineering Requests
(President's Budget – Total Obligation Authority)

	FY09 PBR	FY09 Approp	FY10 PBR *(Constant Year FY09)*	CY Real Change from PBR FY 09
Basic Research (BA 1)	1,698	1,822	1,798 *(1,763)*	+3.8%
Applied Research (BA 2)	4,245	5,090	4,246 *(4,163)*	-1.9%
Advanced Technology Development (BA 3)	5,532	6,537	5,605 *(5,494)*	-0.7%
DoD S&T	**11,4 75**	**13,4 49**	**11,6 49** ***(11,419)***	**-0.5%**
Advanced Component Development and Prototypes (BA 4)	15,774	15,667	14,30 *(14,023)*	-12.5%
DoD R&E (BAs 1 – 4)	**27,2 49**	**29,1 16**	**25,9 55** ***(25,442)***	**-7.8%**

Table 1

FY 2010 continues the trend of moving investment from kinetic to non-kinetic capabilities. As with the past several years, the Department made a deliberate decision to increase investment in the Services relative to the Agencies and Office of the Secretary of Defense. Consequently in this year's budget request, the Services once again account for more than half of our total S&T investment. Embedded within FY 2010 budget are a number of areas of increased investment. These include:

Medical S&T (enhancements in Army, DARPA, and Defense Health Program. The Medical S&T (6.1-6.3) enhancements of $484M in FY 2010 address research needed for improvements in casualty and family medical care (DHP $95M; Services $242M; DARPA $144M; Defense-Wide $3M). This medical S&T investment builds on research in areas such as clinical approaches to poly-trauma, prosthetics, tissue, limb and organ regeneration and prevention, diagnosis, treatment, mitigation and rehabilitation of traumatic brain injury, post-traumatic stress order, and military eye injuries.

Expanded Cyber Protection (DARPA, Services). Allocates about $50M per year to fund information assurance science and technology for intrusion prevention and detection of the department's critical networks in support of the Global Development of the Force Study S&T findings.

Expanded Anti-Tamper Technology (Air Force). Funds $32.6M in FY 2010 for vulnerability assessments of critical program information, verification and validation of

protective procedures and techniques, and development of new technologies to improve anti-tamper capabilities. Special attention is being focused on making commercial-off-the-shelf components and technologies more tamper resistant.

Stand off Detection of Fissile Materials (Defense Threat Reduction Agency). The FY 2010 increase of $40M enhances the proliferation prevention of fissile materials.

Large Data Handling Capabilities (Defense-Wide) Joint Data Management S&T investment of $10M in FY 2010 supports advanced research to improve the handling of large and increasing amounts of information supporting current and emerging warfighting missions. This effort will seek new and novel ways to architect information processing pipelines and exploit other point solutions emerging within the research base. This research program will conduct independent objective quantitative assessments to demonstrate the improvements made in data management and exploitation. These assessments will explore ways in which the Department improves both in technical performance and in warfighting effectiveness.

Sociology Research (Army as Executive Agent -- project called Minerva). Adds $20M in FY 2010 for a DoD and National Science Foundation partnership to develop intellectual capital in the university-based social science research and to further establishing relationships with universities, research institutions and individual scholars to address topics in the social sciences that are of strategic importance to national security. Core Minerva funding is being executed by Army Research Office to continue growing the Department's internal capacity.

High Performance Computing Modernization (Defense-wide). In FY 2010 an increase of $10M funds continued operations at High Performance Computer Centers which increases net supercomputing capability by 50%. This will allow the RDT&E community to conduct more in-depth and a greater number of science-based simulations impacting basic and applied research, systems development and test and evaluation.

Power and Energy (Mostly Army). Energy security is a high priority focused on the S&T strategic goals of reducing platform energy consumption, developing more efficient power sources, enabling smart energy management, developing proactive thermal management, and developing and evaluating alternative fuels. The FY 2010 S&T investment funds efforts in the development of high power and high energy density components, power and thermal management technologies for platform power and higher efficiency electrical components for electronics and power generation.

Cognitive and Neurosciences (Mostly Army). Advances research in the human nervous system to develop technologies that exploit the capabilities of the nervous system structure and function to improve and optimize soldier-system performance. FY 2010 S&T funding investments in the fields of neuroscience, human factors, psychology and engineering will enhance our understanding of brain function and behavior outside the confines of standard research laboratories for development of tools to optimize information transfer between the external systems and the Soldier, identify mental processes and individual differences that impact mission-relevant decision making, and

develop technologies for individualized analyses of neural-based processing in operational environments.

Composites (Air Force). In FY 2010, about $35M will fund the Advanced Composite Cargo Aircraft (ACCA) platform to assess and validate the structural behavior and cost impact of using large out-of-autoclave composite component(s) as a primary structure. Funds are being used to validate the design tools that characterize the performance and behavior of the material, along with reliability testing of a replicate fuselage barrel section to characterize the performance of the design over time.

Changes in World-Wide S&T

As previously stated, Secretary Gates characterized challenges facing our nation and the Department of Defense, changes which have led him to personally shape the Defense Department's budget. Embedded within the changes in the worldwide geopolitical and economic landscape are significant shifts in the global science and technology landscape. These S&T changes consequently impact the Department's investment projections. There are numerous factors that, combined, make this a complicated and ambiguous time for S&T. Such influential trends escalate technological risk, and most of the trends are not something we can do anything about. Taken together, they culminate in an increased risk of technology surprise, and underlie the priority of S&T outlined by Secretary Gates. This priority, in turn, supports the need for the Department to maintain a robust S&T investment. These risk factors include, but are not limited to the following four themes:

1. **Increasing world-wide generation of scientists and engineers relative to the US and Europe**

It can easily be said, and supported with data, that the rest of the world is getting smarter. As world populations rise, the rate of doctoral degrees in the natural and physical sciences is growing in China at a rate that is increasing twice as fast as that in the US. While the number of U.S. doctoral degrees awarded in science and engineering has increased three decades in a row, virtually all of the recent growth reflects a rising number of degrees to non-U.S. citizens: 60% in engineering and computer science and nearly 45% in the physical sciences. Additionally, the ability of the US to attract the world's brilliant minds continues to fall as the rest of the world's institutions of higher learning expand and improve. According to the National Intelligence Council report "Global Trends 2025 – A Transformed World," it is educational opportunity that underpins innovation in the US along with several other key characteristics of our free market society. This is evident in two specific trends associated with education. In 2006, for the first time in history, the US fell behind the UK in ability to attract and educate foreign born scientists and engineers in country and according to the National Science Foundation the percentage of foreign born scientist and engineers that return home is continuing to rise.

2. Growth in world wide R&D investment relative to the US

According to numerous data sources and forecasts by the government and industry the Global growth of R&D spending is expected to continue despite the global economic downturn. While the US spending has slowed, Asian countries continue to grow their share of global R&D. Further, R&D spending and forecast data which show that after peaking in 2004, the amount of in sourcing funds for U.S. R&D has steadily declined one to two percentage points per year.[3] Specifically, R&D spending in China is expected to be more than 1.5% of GDP. This becomes significant because China's R&D expenditures are projected to grow at a rate of just over 6% in 2009 while the rest of the world is contracting. Fundamentally, according to National Science Foundation Science and Engineering Indicators (2006), R&D investment in the rest of the world has grown at three times the rate of the US. Despite the recognition of the US as a country with the world lead in innovation opportunity, this trend is expected to continue as a large percentage of multi-national companies have plans to build leading edge research and development facilities, not just manufacturing facilities outside the US.

3. Increasing use of commercial technology

A number of critical uncertainties in the global technology landscape are centered on the acceptance, availability and proliferation of commercially available technology. In earlier years, many high technology items were expensive and were only within the fiscal purview of military organizations and nation states with sufficient economic strength. In the last decade S&T has become commoditized and global technology distribution, linked with the formulation of global policy provides individuals, small groups, non-state actors and non-government organizations the ability to harvest commercial high technology in new ways to generate capable systems on par with military equivalent capabilities. It is interesting that the terrorists operating in Mumbai used all commercial technology to include commercial cell phones.

Several commercial technology hybrids were identified recently to have potential impact for Department consideration. These include bio-genetics, energy technology, advanced robotics and internet offshoots. In each of these the US position has become one of a high technology net importer. This means that the spectrum of technology options controlled external to the US has the growing potential to generate technology surprise and disruption due to applications and uses.

4. Accelerated pace of technology development

Given current demographic trends and the increasing quantity and quality of science and technology around the world, the rate and pace of technology development is increasing at a non-linear, almost exponential pace. Five years from now, it is projected that you will see some leading technology being developed first in India or China and

[3] "2009 Global R&D Funding Forecast", Battele and R&D Magazine Report, December 2008, Inset Chart Caption, Page 22

flowing back to the West.[4] With the acceptance of mass collaboration and the maturation of multi-country consortia, emerging technology is accelerating from the laboratory to application at an alarming rate. As an example in 2004 one of the first functional metamaterial structures able to "hide" an object went from the laboratory bench to a working prototype in less than 6 months. In Africa, due to the lack of land lines, the use of cellular devices is expected to go straight to 4G capability skipping generations of communications technology. In the area of Quantum Information Science the race to distribute quantum keys to increasing wireless distances has moved from the laboratory at a couple of meters in 2007 to a successful demonstration by Austria's Institute for Quantum Optics and Quantum Information who this month managed to send entangled photons 144 kilometers (90 miles) between the Spanish islands of Las Palmas and the Balearics.

These factors have led the Department to substantially shift our investment over the past three years as articulated on April 6th by Secretary Gates.

Secretary Gates' Strategic Principles and the Relevance to Defense S&T

Basic Research

As mentioned, the first strategic principle articulated by Secretary Gates is the importance of basic research to the future of the DoD. Over the past two budget requests, the Department has increased basic research over 16% and 4% respectively. In order to coordinate the investment, the S&T Executives of the Department developed and implemented a white paper to guide the execution. This white paper provided basic research focus areas for which we have chosen to focus our efforts around. These areas are:

- Cyberprotection and information assurance
- Network sciences
- Science of autonomy
- Information fusion and decision science
- Biosensors and biometrics
- Human sciences (including social science)
- Software sciences and materials
- Immersive sciences for training
- Power and energy management
- Counter directed energy weapons

We would now like to highlight some aspects of the current program. DoD Basic Research provides an essential source of new knowledge and understanding in science and engineering areas that underpin national defense. Today's science and engineering

[4] Beyond the Borders – The Global Innovation 1000

research leads to tomorrow's new technologies, which in turn transforms tomorrow's battlefield. In this globally connected S&T world, we need to be assured that US applies its intellectual and technological resources to keep ahead of a determined and sophisticated adversary.

Transforming the battlefield to keep the US capabilities superior means going back to the basics. The Secretary focused on Basic Research in a time of great demands on budgetary resources to meet operational and other near term purposes. That reflects our belief that the Department needs to aggressively tap into the capabilities of the research community if the U.S. military is to continue to maintain the technological superiority over potential adversaries that has been a hallmark of our national defense strategy for half a century. To cite just a few examples of the research opportunities that the increased investment in FY 2009 has enabled us to pursue:

- The computing and communication capabilities made possible by quantum physics have significant potential impact on information processing, assurance, and exploitation for the DoD. The additional resources available to this topic area have initiated research into discovering, understanding, and exploring small entangled quantum systems for their capability to sense and measure beyond fundamental classical limits. The research involves some of the most fundamental and difficult aspects of quantum physics carried out by leading scientists and institutions in a variety of physical systems, such as trapped atoms and ions, photons, superconductors, and semiconductors. The benefits for the DoD are a potential new class of capability in *cyberprotection* cryptography, sensing and metrology, such as gravity gradiometers, clocks, magnetometers, gyroscopes, detectors for very low electromagnetic radiation.

- In support of increased investment in *energy and power management* research, DoD funds research in heteroepitaxial thin film semiconductor growth that will directly contribute to power generation (solar cells) and energy conservation in communications and chip-to-chip data. The current research offers to provide a real breakthrough in the development of high conversion efficiency solar cells and lower power electronics including silicon-based optoelectronics for telecommunications and computing, areas that are very important for DoD.

- In *information assurance* major advances are being made by the Air Force in the rapid forensics of cyber attacks to enable timely and effective responses, as well as to reliably predict attacks. The Air Force also sponsors research in the active defense of cyberspace and controlled out-of-band communications, such as steganography.

- The Army Research Office's Historically Black Colleges and Universities/Minority Institutions (HBCU/MI) program supports two science, technology, engineering, and math (STEM) programs – the Core HBCU/MI program, and the Battlefield Capability Enhancement Center of Excellence (BCE COE) program totaling over $4 million annually. There have been numerous research accomplishments since the inception of the HBCU/MI Core Program in 1980 and the BCE CoE program in 2003,

including recent research into promising new materials for armor protective composites.

- The Minerva initiative, funded in the Army, seeks to increase the Department's intellectual capital in the *social sciences* and foreign area studies, improve its ability to address future challenges, and build bridges between the Department and the academic social science community. To these ends, Minerva brings together universities, research institutions, and individual scholars and supports multidisciplinary and cross-institutional projects addressing specific topic areas determined by the Department. This program will enable the Department to build long-term relationships with universities while attracting a new generation of academics interested in working on issues of interest to defense policymakers.

While these are just a few examples, the basic research investment portfolio as a whole is well focused in areas with the highest potential for long-term military benefit. Therefore, while DoD's investment is a relatively modest 5% of the total Federal basic research investment, it complements other Federal programs and provides the major source of funding in selected disciplines or subdisciplines. In relation to the total Federal investment in basic research performed by universities, DoD provides 65% of the total in electrical engineering and 85% of the total in mechanical engineering.

It is important that the Department maintains a vigorous program of world-class basic research in universities, other private-sector organizations, and DoD laboratories. Basic research performed in universities is especially important because it is an integral part of the education and training of scientists and engineers for the nation's defense workforce. DoD supports more than 9,000 graduate students in defense-critical fields, largely through the Basic Research program.

Investment in basic research should continue to be a high priority for the Department.

Taking Care of our People

In his April 6th speech, Secretary Gates cited the first priority as "Taking Care of our People." In his speech, Secretary Gates highlighted areas such as enhanced medical care; research and development; improved housing; and so forth. Several of these are elements have clear aspects that are firmly in the S&T realm, including:

1. Medical R&D and Wounded Warrior
2. Training Initiatives[5]
3. Science, Technology and Mathematics Education and Workforce Shaping[6].

[5]Not specifically cited in taken care of our troops in Secretary Gates' speech; but, we content they meet the intent

[6]Not specifically cited in taken care of our troops in Secretary Gates' speech; but, we content they meet the intent

1. Medical R&D and Wounded Warrior Activity:

The most significant way that the S&T community is addressing Secretary Gates charge to "take care of our people" is medical research and development. About 18 months ago, in recognition of the exceptional importance and urgency of improvements in combat casualty care, the Department conducted an extensive review of medical research and development. This review was jointly chaired by the Office of the Director, Defense Research and Engineering (ODDRE), the Joint Staff and the Assistant to the Secretary of Defense for Health Affairs. This review used the Joint Force Health Protection Concept of Operations to focus the effort. Wounded warrior focus areas of Traumatic Brain Injury (TBI), Post Traumatic Stress Disorder (PTSD), prosthetics, eye injury and other deployment and battlefield injuries, provided a key context for the assessment. A JFCOM-led capability assessment had identified over 200 gaps in Joint Force Health Protection. Of these gaps, about 30 percent (69 of 229 were assessed as having medical R&D solutions and only 1 of these R&D-relevant gaps was adequately addressed by the FY 2009 budget. The assessment resulted in the justification for a medical R&D budget increase. The majority of the increase in the FY 2010 budget request was placed in the Defense Health Program (DHP). In addition to the DHP increase, a program reallocation from within the Defense Advanced Research Projects Agency (DARPA) and additions to the Army and Navy RDT&E budgets results in the approximately $500M aggregated increase in the Department's medical R&D portfolio. The increase is wholly assigned to emergent capability gaps directly applicable to wounded warriors and to associated requirements from Congressional directions over the past two years.

The increase to the Department's medical R&D funding request will be used to advance the state of medical science, technologies, and practices in those areas of most pressing need and relevance to today's battlefield experience. Early emphasis will be on psychological health, traumatic brain injury, prosthetics and rehabilitation, restorative eye-care, poly-trauma and supporting medical information and training systems. These areas align with direction that Secretary Gates gave to the Department in June 2008. Research projects will be selected for funding using a competitive process where Department of Defense researchers, industry and academia will submit proposals for specific research and development projects. By using this process, the most promising and expedient medical solutions will be developed and fielded for the Joint Force. The program has a significant new allocation of budget in the 6.4 category for technology transition, clinical applications, and product development. This allocation in a new DHP advanced capability development and prototyping (6.4) program element will ensure that the results of many years of core medical science and technology and the recent large allocations in the supplemental appropriations have resources for transition into medical practice. The governance of this expanded medical R&D will be through the established mechanisms of the Armed Services Biomedical Research Evaluation and Management (ASBREM) Committee which is chaired by the DDR&E and co-chaired by the Assistant Secretary of Defense for Health Affairs. This Committee was recognized by Congress some 15 years ago as the venue for cross-Department coordination and cooperation of

medical R&D. We are committed to sustaining and strengthening the ASBREM Committee's governance role.

In addition to the focused wounded warrior initiative, it is important to recognize the progress made through DDRE-managed programs over the past several years. One highlight comes from the Office of the Secretary of Defense (OSD) Manufacturing Science and Technology (MS&T) Prosthetic and Orthotics Manufacturing Initiative (POMI) which addresses the medical practice at Walter Reed and The Center for the Intrepid at Fort Sam Houston, Texas military medical installations where our nation's most deserving receive care. The POMI effort will characterize and combine new resin materials for increased durability and comfort with new automated manufacturing processes to provide custom composite sockets that can be repeatably produced. Today, fit and performance rely on a hand-made labor intensive process with a prosthesis craftsman, resulting in each socket performing uniquely from provider-to-provider. The new processes will minimize the labor intensive fit-make-fit adjust-fit-adjust cycle for each socket and enable replacement sockets to be produced exactly like the original socket, ensuring consistent comfort from socket-to-socket. Prosthetic devices are then secured to the wounded warrior through use of a custom socket. The tasks included in the POMI initiative were selected as strategic investment focus areas through a road mapping process in partnership with Walter Reed, the Center for the Intrepid, and the Telemedicine and Advanced Technology Research Center. Clearly, these advances present advantages to a much wider population of civilian beneficiaries.

Another example of advances for medical R&D comes from the DoD Foreign Comparative Testing program, a program that seeks out potential solutions from our allies for rapid testing, acquisition, and fielding. Testing of an expeditionary airfield light duty mat system produced by Deschamps, France, enabled the 1st Marine Expeditionary Force and the Army's 10th Mountain Division to establish stabilized landing areas for medical evacuation, and forward ammo and refueling points for rotary-wing aircraft operations. Over 30 systems have been procured by Army, Marine Corps, and the U.S. Special Operations Command for Overseas Contingency Operations. An upgraded matting system is currently being tested to withstand exhaust heat for V-22 employment; when fully deployed in 2010, these mats should enhance combat casualty care across the Department.

The S&T program in FY 2010 demonstrates a strongly enhanced commitment to taking care of the medical needs of the forces we deploy – a force called "our greatest strategic asset" by Secretary Gates.

2. Training Initiatives:

Another way we can support Secretary Gates' priorities to take care of our people is to prepare them for the environmental and operational conditions in forward mission areas. S&T funding supports the Department's efforts to analyze complex cultural and insurgency environments, to experiment with new operational concepts attuned to these

mission conditions, and to devise the doctrine, procedures and training that safeguard our people on foreign and dangerous assignments.

At the foundation of training enhancement is integrated live, virtual, and constructive (LVC) modeling and simulation environments that emulate joint war-fighting conditions across a network of interoperable sites and participants to meet the training needs of the combatant commanders and the Services. The Defense Modeling and Simulation Coordination Office (MSCO), a subordinate office within DDR&E, leads a Defense-wide effort for developing, testing, and maintaining standards for LVC training environments. The LVC environments meld existing operational and strategic applications with live forces and those training in simulators to create a more robust and realistic experience, and allowing our forces to train more realistically before deployment. From networked scenario solutions to unite geographically segregated units for combined pre-deployment training, to immersive environments for cultural awareness and rules of engagement indoctrination. LVC technologies enable more effective mission preparation while managing risk to our warfighters.

Recent M&S Senior Steering Committee (M&S SC) funded training projects have focused on improving the spectrum of distributed training environment capabilities and tools. The Joint Data Alternatives addresses the need for rapid scenario data generation, and will effectively support a variety of training, testing, planning, mission rehearsal, and decision support events. The Architectural Roadmap has recommended a series of actions promoting greater commonality and more efficient environments, leading to reductions in integration costs for distributed M&S. Additionally, the Training for Aviation in Urban Operations addresses today's pressing need for representing urban environments to train and prepare our forces for the conduct of attacks on ground targets with more precision and less collateral damage. These examples of Departments M&S activities are helping the Services and COCOMS train the forces in a networked, distributed environment in which they will fight.

Demonstrations bridge developmental efforts and pragmatic employment of technologies. Training demonstrations are becoming a more important part of our Joint Capability Technology Demonstration (JCTD) Program. In FY08, we initiated the Future Immersive Training Environment (FITE) JCTD project in response to an emergent combatant commander need. This project is delivering integrated, immersive technologies to build training realism and enhance our soldiers' and marines' preparation for Irregular Warfare. We expect this JCTD to deliver FITE JCTD Software; open architecture standards; immersive visual projection (helmet mounted for individual soldier use or wall mounted); specialized sound system (hearing the bullets pass your head, on which side, etc.); Haptic vests (special vest to provide pain and body sensations during uncomfortable immersive situations/environment); olfactory system (smell generator); individual position and weapon tracking system (to provide soldier orientation during virtual and augmented reality training environments) in 2010. These serious training enhancements deliver improved mission capabilities with consequent conservation of travel expenses and time.

We also take care of our people by focusing experiments on understanding the anticipated scenarios of the future to allow the forces to train better. Executed in partnership with United States Joint Forces Command, the Joint Experimentation Program is the Department's pathfinder in developing the doctrines and operational concepts foundational to Irregular Warfare. Joint Experiments are formulated in response to priorities set by combatant commander customers and Service partners with current subjects reflecting the urgent shift to augmenting conventional warfare capabilities with a comprehensive set of Irregular Warfare force constructs and employment options. The overarching Irregular Operations Joint Operating Concept and associated Joint Integrating Concept ("IW JOC & JICs") are under development as Joint Experimentation projects. These efforts will yield the authoritative DoD framework for irregular and complex operations including Foreign Internal Defense (FID), Counter Insurgency, and unconventional warfare developing a greater representation of Irregular Warfare, which allows us to better take care of our people.

3. Science, Technology, Engineering, and Mathematics (STEM) Workforce

A final way the S&T program can be used to take care of our people is to enhance Science, Technology, Engineering, and Mathematics (STEM) Education. As highlighted in the President's speech to the National Academy of Sciences on April 27, 2009, and I'll paraphrase, we are called upon to use our knowledge of science to engage a new generation of scientists and engineers, to enhance teacher preparation and training, and to support inventive approaches to develop new and innovative ways to attract experienced scientific professionals into the classroom. But by expanding our STEM education programs, we provide avenues for returning service members and their families while reducing the stress on today’s civilian and military force.

The education of a new generation in the STEM disciplines in the context of a very competitive world is one of the key challenges of our country, and for the Department of Defense, and the undergirding for our future national security. DoD scientists and engineers account for nearly 50 percent of the entire workforce of Federal scientists and engineers—and we take care of our people by improving the ability to shape the workforce of the future.

It is important to recognize that STEM and outreach have a number of individual programs across the Department and the DDRE staff is involved in improving the Department-wide transparency of STEM programs. I wish to highlight a relatively new but I think successful program initiated in 2006 by Congress: the National Defense Education Program (NDEP). NDEP currently has three major initiatives. The first is the Science, Mathematics and Research for Transformation (SMART) Program which is an undergraduate and graduate scholarship-for-service program. Over the past year, we have transitioned nearly 40 SMART students into the DoD laboratory workforce and funded several hundred of new and continuing SMART students.

The second initiative is the National Security Science and Engineering Faculty Fellowship or ‘NSSEFF’ Program which is a prestigious faculty award Program.

NSSEFF, which began in 2008, is funding 18 top-tier university researchers to conduct unclassified, long-term basic research in areas that underpin future DoD technology development.

The final program is the pre-college math and science program, or PEP, which is engaging and developing students' interests in math and science through inquiry-based activities and LabTV webisodes that introduce our scientists, engineers and cutting edge technology to the K-12 students throughout the country. To date, PEP has provided professional training for hundreds of teachers as well as providing support for our laboratory scientists and engineers (S&Es) in the classroom partnership initiative. Our S&Es and teachers work collaboratively in engaging students in real-world problems.

In FY 2010, SMART will continue to transition students into the Army, Navy and Air Force laboratories and build our near term workforce. PEP will, among other things, expand to nearly 25 States and continue to engage DoD S&Es with students and their teachers. Also in FY 2010, we will issue a new NSSEFF Broad Agency Announcement and make new awards. Although relatively young, NDEP has been received positively from the local to national level. Further, it has been a positive force in the Department as it is a DoD-wide program in which all three Services have been active partners.

In summary, taking care of our people is a cornerstone of the Department. While this is most closely aligned with Medical S&T, there are other areas that provide depth to our forces' understanding of their present (training) and future (STEM) challenges. Taken as a whole, we believe this demonstrates some success, although there is much left to do.

Developing the Capabilities to Fight the Current and Future Wars

The second priority highlighted by Secretary Gates in his April 6, 2009 speech is to "institutionalize and enhance our capabilities to fight the wars we are in today and the scenarios we are most likely to face in the years ahead. What this means practically is that we need to continue the shift of investment capabilities from kinetic to non-kinetic capabilities to meet the special challenges of Irregular Warfare. As outlined in the 2006 Quadrennial Defense Review, and reaffirmed by Secretary Gates, the DoD needs to continue to develop capabilities in a number of new technology areas supporting Irregular Warfare capabilities.

In order to demonstrate how the Department's S&T program supports development of new capabilities, we would like to highlight some recent and future efforts in the following areas:

1. Intelligence, Surveillance, and Reconnaissance
2. Large Data Processing
3. Command and Control and Network Sciences
4. Cyber Protection
5. Social Modeling
6. Irregular Warfare Modeling and Simulation / Joint Experimentation

7. Energy Efficiency for Forward Deployed Forces
8. Other Irregular Warfare S&T Efforts

1. Intelligence, Surveillance, and Reconnaissance

The Secretary of Defense has noted that contemporary warfare, and especially information-based warfare, requires increased intelligence, surveillance, and reconnaissance (ISR) support for our warfighters. To meet this need, the Secretary established the ISR Task Force in 2008. However, the Department's S&T program has been involved in bringing about new ISR capabilities throughout the current conflict.

For instance, ISR has been a focus of the JCTD program – and its precursor Advanced Concept Technology Demonstration (ACTD) program -- for several years. JCTD projects have demonstrated and transitioned both ISR platforms and sensors. For example, the Predator and Global Hawk unmanned air systems grew from Service S&T and early DARPA and Service experiments culminating in ACTDs to demonstrate the capability. Today, our JCTD program is investing in the next generation of unmanned platforms for ISR. An example is the Global Observer, a hydrogen powered, high altitude vehicle capable of carrying multiple sensors simultaneously on missions lasting 10-14 days. Global Observer is under construction now, and is expected to begin flight testing by October of this year. Another is Zephyr, a low-cost, solar-powered vehicle capable of carrying small payloads 5-7 days at high altitude. Zephyr was flight tested in 2008, including a flight of over 82 hours with a communication relay payload, an unofficial world endurance record for fixed wing unmanned aircraft. All of these platform advances could help fill persistent ISR gaps while potentially saving valuable resources. Finally, DARPA has just initiated the Integrated Sensors is Structure (ISIS) program, a program to determine if we can build and fly an extended duration "balloon" at high-altitudes with integrated sensors. This is roughly a four year program, but could revolutionalize current tactics, techniques and procedures.

The ACTD/JCTD program has also been at the forefront of developing sensors that operate in new and expanded domains. Such systems as Hyperspectral Collection and Analysis System ACTD, MAGNUM Polarimetric Imager ACTD, Foliage Penetration Radar JCTD, Airborne Weapon Surveillance System ACTD, and Joint Multi-Mission Electro-optics System JCTD are carried by our ISR platforms today. We continue to develop new concepts, ranging from complex multi-sensor turret systems aboard both manned and unmanned platforms, to miniature hostile fire detection, localization, and classification systems for small unmanned air platforms. One current project integrates multi-spectral and other sensors in a small turret, and includes on-the-fly multi-spectral processing for automated target alerting of concealed targets.

Current technology involving commercial satellite Synthetic Aperture Radar (SAR) imagery is limited by resolution, polarization, and global surveillance coverage. The Rapid Reaction Technology Office (RRTO) is leading the development and testing of the first real-time, low-cost SAR capability for battlefield commanders in small dispersed units. This system should allow us to detect minute changes in terrain,

infrastructure and other human activity, including troop and vehicle movement. The Synthetic Aperture Radar Coherent Change Detection (SAR CCD) capability is intended to produce immediately actionable intelligence by collecting and downlinking in near real time, SAR imagery using a tactical unmanned aerial system (UAS) at a cost of less than $500K per sensor package. Today, no tactical SAR platform with real-time CCD capabilities exists. The initial assessment of the SAR CCD technology demonstrated the ability to detect small (millimeter) changes in terrain left by footprints, vehicle tracks, digging and other human activities. These small changes were often discernable via the SAR but not with the human eye at ground level.

The RRTO also focuses on maturing ISR technologies that support Irregular Warfare needs, not only in support of current challenges in Iraq and Afghanistan, but in anticipation of different environments where we may operate in the future. The RRTO uses funds from the OSD Quick Reaction Special Projects program – a program that allows us to develop and demonstrate novel capabilities within a year to 18 months. The agility of the QRSP program allows the Department to meet emergent needs of the warfighter, and is a vital element of the overall DDR&E investment strategy. This program has placed a special emphasis on ensuring ISR capabilities in development are demonstrated in operational conditions before deploying. In the past, RRTO has helped prepare new capabilities for use in the field by sponsoring test beds and operational experiments at the Yuma Joint Experimental Range Complex, a venue to evaluate how well newly developed capabilities work in a simulated urban environment; and, on Stiletto, a maritime test vessel used to provide developers a way to inexpensively assess operational capabilities of maritime-related systems. Future technology developed by RRTO includes the Pelican heavier-than-air aircraft demonstration, which could ultimately provide a long-endurance lift capability by 2015.

The Foreign Comparative Testing Program is also sponsoring a project with the Defense Intelligence Agency using the commercial, Italian produced COSMO-SkyMed, a constellation of four SAR satellites that provide rapid revisit, 24-hour, global coverage of the Earth. If successful, this will increase the amount of imagery data, at a higher resolution, in a quarter of the time it takes today to get the same image from other satellites. The net result could be more timely tactical support to commanders on the ground. In short, the combination of UAV and space-based SARs should provide an incredible advancement to ISR capabilities.

Taken all together, the collective offices of the DDR&E have worked effectively with the Services to deliver a number of novel ISR demonstrations.

2. Large Data Processing

With the successful ISR demonstrations we have just talked about comes a significant challenge. Data streams amounting to terabytes of information, with the prospect of even bigger data sets in the future, now represent a realistic challenge that must be addressed. Without improving our ability process data and extract actionable intelligence, we run the risk of becoming data bound and information starved. This is

similar to highways—when highways have too many automobiles on them, the system stops working, and people don't move. Similarly, when data saturates communications architectures, finding the actionable information becomes nearly impossible. In recognition of the need to improve data handling capacity, the ODDR&E has identified several promising technical approaches for dealing with extremely large data sets, including techniques such as cloud computing, compressive sensing, dense correspondence algorithms, and topological data analysis. Our FY 2010 budget requests $10M to focus research efforts in this important area; while this is a small investment, we believe it is sufficient, and will pay major dividends.

The JCTD program also invests in novel processing advances to enable our warfighters to make best use of existing ISR information. Some illustrative programs include (1) new processing of data collected by satellites to isolate particular targets, such as the Signals Intelligence Processing ACTD which delivered new algorithms in 2007; (2) the Extended Space Situation Awareness which leverages missile defense and other sensors to improve awareness and tracking of space objects, transitioning in 2010; and (3) the Comprehensive Maritime Awareness JCTD that automatically collects and correlates information from hundreds of sources to assist maritime security analysts in both DoD and DHS, which transitioned to the Navy and US Coast Guard in 2009.

Finally, any improved capacity for handling large data requires experimental data sets. The RRTO has sponsored two major projects, with the Services and other government agencies, to develop very large test data sets—project Bluegrass and Thunderstorm.

Conducted in the Summer of 2008, Bluegrass amassed a significant (50TB) database of electro-optical and ground moving target indicator information collected in urban and rural environments. This database containing ground truth target tracks has been made available to numerous users in the defense community to assist in developing a multitude of ISR related capabilities.

Building on Project Bluegrass we developed a Multi-Intelligence ISR test bed to facilitate development and evaluation of ISR capabilities in a real world environment known as Thunderstorm. DDRE partnered with the Joint Interagency Task Force-South (JIATF-S) to conduct exercises two to three times a year. For each spiral, a set of challenge problems are designed to encourage technology development that will help DoD and JIATF-S "unravel the networks" associated with global threats to national security. Data gleaned from the multitude of sensors and analyses during Thunderstorm will help us in our joint mission to deny drug trafficking organizations (and terrorists) access to funds, supplies, and transportation resources.

The first Thunderstorm spiral will be executed from 9-22 Jun 09 focusing on solutions to pressing issues plaguing operations in and around Central and South America, and Africa. Exercise scenarios, which will involve DoD and interagency partners, will help define techniques to stop high speed boats and detect self-propelled semi-submersible vessels.

As part of Thunderstorm, we are also supporting ISR-related programs. RRTO is sponsoring the use of a low-cost mobile satellite ground station located at JIATF-S's Key West compound, combined with Israel's TECSAR Synthetic Aperture Radar satellite to demonstrate a streamlined, yet decentralized, approach for a theater commander to task and receive satellite images.

3. Command and Control and Network Sciences

Building upon our successes in ISR and data handling capabilities, we are also focusing on improving the command and control and network capacity to move data among dispersed operations.

The DDR&E Networked Communications Capability Program is designed to streamline DoD programs as well as to provide additional capability for today's warfighter. This program in conjunction with the Services has:

- Created and demonstrated a joint federated networking testbed, owned and operated by the government. This testbed is used to develop new network operations (NETOPS) technologies to integrate tactical networks and ensure that NETOPs technologies are "born joint."
- Demonstrated an airborne data and voice relay for small tactical units. DDR&E will demonstrate this recently prototyped package to both SOCOM and CENTCOM this year for possible immediate transition to support the war effort.
- Transitioned several technologies to existing programs of record (JTRS, WIN-T) to enable multiple users to simultaneously receive data and voice. The transition of this technology to different programs will ease integration and promote interoperability once these systems are fielded.

In response to an Urgent Need, DDR&E led the fielding and delivery of a new radio network. The Netted Iridium capability has been developed, delivered and fielded; this capability is a new type of beyond-line-of-sight network for disadvantaged users for use in Afghanistan and Iraq. Forty-four production-ready prototype radios and associated Iridium-based gateway networking technology are currently fielded, and 500 production radios will be delivered by the Army over the next year. This lightweight radio (<2 pounds) ground network provides voice and high capacity data for ground networks for people up to 100 nm apart, regardless of the terrain. The success of this DDR&E-led development is due to the close partnership of the Joint Staff, CENTCOM, and the US Navy (Dahlgren).

Effective command and control requires precise position, navigational timing data. The High Integrity GPS (iGPS) program is developing and demonstrating technologies that enable orders of magnitude improvements in the warfighter's positioning, navigation, and timing (PNT) anti-jamming (AJ) capabilities. The program exploits features currently available in the commercial Iridium satellite constellation and is an augmentation to the current and future GPS constellations. The focus is on the

development of technologies that (a) utilize ranging data from the rapid angle motion of the Iridium satellites for geo-location, (b) enable coherent integration of the GPS carrier phase signals for up to a 30dB increase in anti-jam performance, and (c) demonstrate satellite spot beam control to provide enhanced PNT capabilities in dense canopies, mountains, and urban canyons. Field tests with brassboard hardware in a moving vehicle have successfully demonstrated a two orders of magnitude increase in GPS AJ with decimeter position precision. Oversight of the iGPS program is led by the Deputy Under Secretary of Defense for Science and Technology and executed through Office of Naval Research by Naval Research Laboratory. SOCOM is providing input on user needs and assisting in field testing.

4. Cyber Protection

During the last year, DDR&E has championed the DoD's increased S&T efforts to address military cyberspace security. Prompted in part by calls from Congress and Executives from both the current and previous administrations, the DDR&E staff has implemented a $100 million per year investment increase. The program has a number of objectives, to include:

- Identified gaps and initiated new science and technology research executed by the Components to build technologies to defend our critical military networks from cyber attacks
- Championed DARPA's new efforts in cyber security and information assurance
- Reinvigorated DoD's science and technology efforts in all dimensions of cyber warfare.
- Actively engaged with the Office of Science and Technology Policy to lead interagency coordination to identify and develop leap-ahead technology for national security
- Enabled many small innovative companies to develop solutions for DOD cybersecurity challenges through the Small Business Innovation Program

While the details of the specific projects are classified, we are dramatically increasing our attention on this important area.

5. Social Modeling

As noted previously, we have initiated a social modeling basic research program called Minerva. To complement Minerva, we have the more mature OSD Human Social Culture Behavior (HSCB) program.

In its first year, HSCB modeling program rapidly established a foundation for success and begun delivering new initial capabilities to DoD users. The program is comprised of a Senior Level Users Group, an Integrated Project Team, and five technical working groups. A test bed for technology integration experiments and operational feasibility demonstrations has been established at the Army Geospatial Center. Building on this foundation, the program has moved quickly to identify and support cutting edge

research to develop computational models of social, cultural, and behavioral factors, and model-driven tools that can be transitioned to DoD programs of record. Funded work has already yielded some high impact success stories; Sentia Corporation's Senturion influence models were instantiated in PACOM/SOCPAC planning; Carnegie Mellon University researched and enhanced social network analysis tools that were transitioned to USSOCOM; and the US Army Corps of Engineers applied the Measuring Progress in Conflict Environments framework to the Haiti Stabilization Initiative.

Another novel JCTD, called Mapping the Human Terrain (MAP-HT) is providing tools for collecting and processing social and cultural information in 2009 and 2010, enabling appropriate consideration of social and cultural factors in military decision making. Using manual techniques available to date, this capability has proven to be especially useful in operations in Iraq.

6. Irregular Warfare Modeling and Simulation/Joint Experimentation

DoD is supporting our ability to fight in new situations such as Irregular Warfare by investing in high-priority modeling and simulation (M&S) activities that enhance our warfighters' training and understanding of the adversaries, neutrals, and the physical and social surroundings. High-level tasks funded for FY 2009 include coordinating the development and dissemination of tools for Irregular Warfare and managing our priority standards. Specific projects are encouraging collaboration, supporting efficiency and reuse, and reducing duplication.

We have already established the M&S Irregular Warfare Senior Coordination Group (M&S IWSCG) to fund projects in an area where we are underinvested and potentially vulnerable. This group is leveraging the existing DoD M&S governance structure to enhance visibility, collaboration and coordination of IW M&S. The M&S IWSCG is coordinating the development of tools, data and services that will allow us to address current and future IW challenges.

We are establishing the M&S standards that will allow the warfighter to access needed tools efficiently, easily, and quickly for timely applications when and where needed. Also, our work creating a standardized synthetic environment (through the Environmental Scenario Generator) provides the IW planners and analysts M&S-ready databases representing the air, sea, land, and space environments uniformly across the mission space.

Research, Development, Test & Evaluation funding underwrote the Department's earliest efforts to analyze and understand the emergent world of Irregular Warfare and continues to propel innovative concepts and capabilities into the hands of today's warfighters and peacekeepers. The Joint Warfighting Analysis Program (JAWP) delivered seminal studies outlining the need and form of new military capabilities evolving into today's Irregular Warfare roadmaps. Direct analysis support to theater commanders conducting Operations IRAQI FREEDOM and ENDURING FREEDOM produced a series of strategic and operational benchmark references including

"Indigenous Forces in Irregular Warfare," "Iraqi Terrorist Perspectives," and "Global War On Terrorism - Horn of Africa Lessons." Current DDR&E-funded JAWP efforts develop concepts and capabilities to fill gaps that senior officers identify as important and that joint force commanders struggle to perform: sustaining distributed deployed basing, planning economic campaigns, planning indigenous population influence, and countering police/security force corruption.

Other programs supported with RDT&E programs provide pivotal capabilities empowering a new generation of joint operations. The Joint Fires Integration and Interoperability Team (JFITT) troubleshoots technical and procedural issues in the demanding realm of joint close air support producing mission-tailored tactical capabilities such as cockpit-to-ground target designation links and integrated sensor sources for target detection and engagement. Other DDR&E programs executed in partnership with USJFCOM such as Joint Integration and Interoperability (JI&I) and Joint Systems Integration Command ("JSIC") are the main resource accounts for joint command and control capabilities amalgamated from Service solutions.

7. Energy Efficiency for Forward Deployed

As evidenced by the increased emphasis on energy security activity in the DoD, the Department-wide S&T investment in energy related technologies continues to increase in importance. Energy consumption affects both tactical operations and strategic decisions of the DoD. In response, the Department developed and is coordinating an energy security that contains four primary goals—the first two of which apply to the S&T investment of the DoD. They are:

- Increase operational capability by increasing energy efficiency, and
- Assure supply of energy

While the topic of technology for energy security has recently been the subject of several hearings, we would still like to highlight a few key activities.

In the summer of 2006, then Major General Rick Zilmer, commander of the deployed Marine forces in Al-Anbar Province Iraq, issued a Joint Urgent Operational Need (JUON) statement that said “reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys.…Without this solution [renewable energy systems], personnel loss rates are likely to continue at their current rate." In response to this request, the Army Rapid Equipping Force (REF) established the Power Surety Task Force to determine what could be done to address this need. They discovered there were few “turnkey” ready capabilities applicable to the harsh operating conditions at a forward operating base.

When Maj Gen Zilmer discussed the need to reduce the fuel demands of forward operating bases, he did so because the Army (and forward deployed ground forces in general) use more fuel to operate ground generators at forward bases than they use for any other system, including helicopters and ground vehicles. According to a 2008

Defense Science Board study, the total amount of fuel consumed by generators has jumped from 26 million to over 350 million gallons to operate bases in Iraq and Afghanistan. This usage rate led to the Net Zero JCTD, which is sponsored by the US Central Command, which will demonstrate prototypes of technologies (wind, solar, other renewables) over a 3 year period that could, collectively, use less energy than they create. The JCTD will determine which, if any, should be recommended for inclusion in sustainable design efforts in DoD installations and tactical bases. By reducing demand, providing efficient distribution, and using alternative energy sources, the FOB should be able to minimize fuel consumption, and ultimately save lives through the reduction in the number of fuel convoys required.

While petroleum demands at ground sites have increased, aircraft engines are still the DoD's greatest single consumer of energy; they consume over 50% of all energy used in the DoD. The Air Force is developing technologies with industry to increase jet engine efficiency. The Highly Efficient Embedded Turbine Engine initiative is developing a high-pressure ratio, high temperature core turbine technology, with the potential to reduce specific fuel consumption up to 25% over today's turbine engines. The current schedule includes a rig test in FY 2010. These technologies are applicable to all turbine engines and could be used in commercial aircraft.

Another project I would like to mention is the DARPA-led effort to develop and test various feed stocks for synthetic jet fuel that would have the same energy density as current petroleum-based fuels. DARPA initiated a $100 million program to further development of affordable algae-based synthetic fuels (synfuels), with the goal of driving the cost to $2 per gallon in 18 months. In December 2008, DARPA awarded two contracts to determine the state of the art. If successful, the DARPA solution could lead to carbon-neutral assured source of domestically produced JP-8 jet fuel, providing stability to the price volatility of fuel.

In addition to aircraft, we have on-going projects throughout the Department to address fuel consumption associated with the mobility of our ground forces. The Army's Tank and Automotive Research and Development Center (TARDEC) in Warren, Michigan is $40 million program centered around the ground vehicle Fuel Efficient Demonstrator (FED). The FED is testing the feasibility and affordability of achieving significant decreases in fuel consumption (30 to 40%) in a tactical vehicle while maintaining or increasing mission capability. This program is integrating potentially high-payoff fuel efficient technologies, like efficient propulsion and drive trains, and advanced lightweight materials in new and innovative designs, and will test prototypes over the next two years.

A final area of interest is batteries. We mention this because of the recently completed "Wearable Power Prize". Currently one of the more significant limitations for our irregular warfare ground operations is available power. A typical dismounted warrior on a four-day mission carries between 20 and 50 pounds of batteries and rechargers. The DoD has invested in the research and development of many energy technologies including, secondary batteries, air-breathing batteries, solid oxide-, direct methanol- and

hydrogen- fuel cells with great success. The Wearable Power Prize competition captured these investments and extended the technology towards a more system-centric focus where the integration of the power technologies with material and power management techniques were demonstrated.

The competition was announced in the summer of 2007 resulting in over 169 teams registering to win the $1M prize for a wearable system that produced 20 watts average power continuously for 96 hours and weighed less than 4 kg (8.81 pounds). Ultimately, 20 teams, of which 35% were from non-traditional backgrounds without a previous relationship with the DoD and without corporate affiliation, participated in the capstone event at the Marine Corps Air Ground Combat Center in Twentynine Palms, California.

At the conclusion of the 96 hour test phase, five teams had completed the competition metrics with remaining power to spare. The top three winners, as determined by the lightest weight, were the DuPont/Smart Fuel Cell team's methanol fuel cell hybrid weighing 8.29 pounds followed by Adaptive Materials Inc and the Jenny 600S team at 8.35 and 8.51 pounds respectively. The top three teams were awarded $1,000K, $500K and $250K.

Many of the component technologies featured in the competition were already known to the DoD and variants are being funded through mechanisms such as the Program Executive Office (PEO) structure. Other approaches are in various stages of R&D. In this sense, the competition validated DoD's investment in technology components while offering novel approaches to the integration of materials and components. The competition produced prototype systems that show great promise for dramatically reducing the weight of the power systems warfighters must carry while performing their critical missions.

The Defense Acquisition Challenge (DAC) program creates innovation, serving as an "on-ramp" to companies who may not be major DoD contractors. DAC testing enabled a non-traditional defense supplier to provide Army soldiers with a methanol fuel cell power system for a small, advanced, high-power, light-weight, wearable power source for use in military operations. This device offers a revolutionary new power source for individual soldier use during military operations, up to 80 percent lighter than conventional power sources, with the potential to extend a soldier-mission to 72 hours. Initial units are currently deployed for limited Army evaluation in Afghanistan.

8. Other (Irregular Warfare) S&T Efforts:

While we have thematic investments, I would like to close by discussing a few additional significant efforts. The Department's S&T investments in directed energy systems have achieved, in recent months, tactically significant laser power in electric laser devices. In a cooperative effort and with funding from the Army, the Air Force, and the Department's High Energy Laser Joint Technology Office, competitive contractor development of high power electric lasers has demonstrated greater than 100 kW power,

for long durations (>300 seconds per shot at 100kw demonstrated frequently), and with excellent repeatability. The laser-on time since February of this year has exceeded 120 minutes, sufficient for "kill" 1400 targets. This advancement in electric laser technology enables attendant advances in applications for battlespace awareness, force protection and force application missions. In addition, the Department's High Energy Laser Joint Technology Office (JTO) continues to press associated advances in optics, solid state devices, controls, lethality studies, and advanced concepts to ensure this technology is brought to sufficient technical readiness to transition to the battlefield.

The Department's rotary wing vehicle S&T portfolio is supporting the warfighter today by providing advanced technologies for current and development systems. For example, the recently completed Rotorcraft Drive Systems for the 21st Century (RDS-21) program developed two different concepts for advanced drive systems that are starting to provide benefits in DoD aircraft. One of these concepts is now in production in the AH-64 Apache Block III. The other concept is in development for the CH-53K program, providing greater power at lower weight. Continued improvements in drive system weight, power, and durability are being sought in the on-going Enhanced Rotorcraft Drive System program. At the same time, our S&T program is leaning forward by participating in the Capabilities-Based Assessment (CBA) and planning effort called out in Section 255 of the Duncan Hunter National Defense Authorization Act for FY 2009. My staff is leading a team of S&T experts from across the Department and NASA to develop the requested S&T plan, and the team has recently developed a capabilities-based framework to help them integrate their efforts and communicate with the teams working on the CBA and Strategic Plan, and ultimately lay a solid foundation for the future of vertical lift for the Department and the Nation.

The Joint Technology Office on Hypersonics (JTOH) works with the Services and agencies to support a series of major flight test activities. The X-51A Scramjet Engine Demonstration program will test the Air Force/DARPA hydrocarbon fuel-cooled scramjet engine in flight operating from Mach 4.5 to greater than Mach 6, with 4 tests currently planned in FY 2010 starting with the first flight in October 2009. The DARPA/Air Force Falcon Hypersonic Technology Vehicle (HTV-2) program will flight test two boost-glide vehicles demonstrating technologies to achieve significant downrange, large cross-range, and accurate navigation, with the first flight planned for late this summer and the second flight early in 2010. The Navy/DARPA Hypersonic Flight (HyFly) program looks to flight test dual-combustor ramjet technology for missile applications at speeds up to Mach 6. After two flight test failures in 2007 and 2008 due to technical difficulties, DARPA recently added funds for an additional flight in 2010. Finally, the Navy's Revolutionary Approach To Time-critical Long Range Strike (RATTLRS) program looks to flight test high-Mach turbine propulsion technology at flight velocities greater than Mach 3 for missile applications. The propulsion system has experienced technical difficulties in ground test, but the Navy is exploring options to pursue flight testing in 2010. Collectively, these flight test activities will demonstrate the maturation of technologies we have been working on for several years and provide the foundation for future efforts in combined cycle propulsion and advanced vehicle concepts. In addition, these flight tests define a backdrop for a number of studies that are

considering potential requirements for high-speed and hypersonic technologies. The JTOH is currently updating its roadmaps in accordance with the 2007 John Warner National Defense Authorization Act.

Improving our Acquisition Process

The third and final priority highlighted by Secretary Gates is improving our acquisition process and accountability. There have been numerous "blue ribbon" studies pointing to the challenges facing our acquisition program. There are several areas of potential improvement where the DDR&E team can play a key role:

1. Technology Maturity Assessments
2. Rapid Acquisition
3. S&T Integrated Priority List
4. Agile Information Tools
5. High Performance Computing
6. Manufacturing Technology

1. Technology Maturity Assessments

A fairly consistent theme in a number of troubled acquisition programs is lack of technical maturity in that program. Acquisition programs such as the Space Based Infra-Red Satellite System, Future Combat System, Transformational SatCOM, Airborne Laser, and others all had technically immature components or critical technologies at Milestone B. The Department addressed this challenge in the recent revision to DoD Directive 5000 series by directing expanded use of technology reviews and technology maturity assessments at or before Milestone B. In the current system, if we are surprised by immature technologies at Milestone B, we have a failure of the process. To minimize these surprises, we have dramatically expanded the use of Joint Analysis Teams and Defense Support Teams to specifically address focus areas in the technology base or early acquisition programs.

Technology Readiness Assessments (TRAs) have been used by USD (AT&L) to support of DoD acquisition decision-making and to certify technology maturity at Milestone B by USD (AT&L). TRAs have been very effective in the identification of technology readiness issues prior to acquisition decision points, thereby focusing attention on mitigating any such deficiencies. In many cases, immature technologies have been identified that led to additional technology testing and validation in operationally relevant environments. Also, TRAs have often clarified ambiguities in system requirements and needed capabilities that might otherwise cause serious problems during program execution. Lessons on how to conduct more effective assessments are being continually learned from past assessments, and are captured in the TRA Desk Book to assist current and future acquisition programs.

Complementing the formal Technology Maturity Assessments are defense support teams (DST) and joint analysis teams (JAT). In December 2008, the Office of the

Secretary of Defense mandated two new categories of these two teams. The DSTs and JATs are comprised of world-class Government and contractor technical experts from the technology development and management disciplines. The DSTs and JATs leverage the unique expertise and understanding these individuals possess in the disciplines of science, technology, engineering, manufacturing, and program management. The teams' roles span from giving advice and assistance to program managers and engineers in resolving complex technical challenges with major DoD acquisition programs, to defining strategies and roadmaps for the development of technologies or mission capabilities for the entire defense enterprise. The differences between the two types of teams are primarily attributed to the breadth and scope of each team's charter and tasks. DSTs focus on solving a specific technical problem that could assist high-risk, troubled programs in getting back on track; whereas JATs look at cross-cutting activities that impact multiple programs and requirements. DSTs and JATs that are completed or underway now number in the dozens. Many programs and DoD investment areas are benefiting from the support team concept. We will highlight four recent teams for which DDR&E was chair or co-chair responsibility.

- Electromagnetic Aircraft Launch System (EMALS) DST - established to assess the development maturity of the EMALS program and its ability to support the CVN 78 production schedule. The DST identified eight findings with actionable recommendations for the Navy to implement to reduce schedule risks; the program risk has been reduced.

- Networked System Security Certification (NSSC) JAT - established to address the acquisition challenges associated with evolving (security) certification requirements. The NSSC JAT recommendations for improvements were accepted by the USD(AT&L), who directed that they be implemented immediately with progress reported back to him within 120 days.

- Nuclear Defense (ND) JAT - established to explore DoD mission, authorities, guidance and options related to nuclear defense and to make recommendations on investment strategies and management approaches. The ND JAT recommendations led to guidance from the USD(AT&L) to endorse Assistant to the Secretary of Defense for Nuclear, Chemical, & Biological Defense Programs as the principal advisor for global nuclear defense and to establish a global nuclear defense steering committee and permanent working group to develop and implement the recommendations of the JAT.

- F135 JSF Engine DST - As the Congress is aware, the F135 engine suffered two blade failures in the 3rd stage low pressure turbine during testing in late 2007 and early 2008 for powered lift in support of STOVL operations. These failures were traced back to high cycle fatigue and linked to a phenomenon known as mistuning. Mistuning is a difficult problem that has been researched since the 1960s, but in the last several years the Department, working with the gas turbine industry and academia, has made great strides in understanding this complex issue. The F135 JSF DST consists of experts from the Air Force and Navy and an

external independent review team. The team worked with the program office and Pratt and Whitney to identify the most probable root cause and applied their understanding of mistuning to establish a plan to resolve the issue while minimizing redesign and the subsequent cost and schedule impacts. The program is now implementing this plan and looks to fly STOVL operations later this year.

2. Rapid Acquisition

The two key components of rapid acquisition are the generation of urgent operational needs and the corresponding acquisition processes used to fulfill those needs. The 2009 NDAA directed two studies in these areas. First, Section 801, Assessment of Urgent Operational Needs Fulfillment, asked the Secretary of Defense to commission a study to assess the effectiveness of the processes used by the Department for the generation and fulfillment of urgent needs. Secondly, Section 253 directed the USD (AT&L) to perform an assessment of technology transition programs in the Department of Defense to determine if consolidation of these programs into a more unified effort would be beneficial. We are generating these two assessments as we continue to improve our processes in ways that adapt to a changing threat within the context of budgetary realities.

3. S&T Integrated Priority List

Finally, the S&T community can enhance the Department's acquisition process by improving early identification and dissemination of warfighter priorities that can be addressed with S&T. In our effort to decisively address the current war, validated joint military capability requirements drive responsible resource decisions. S&T development and technology transition for tailored capabilities stand a significantly higher probability of success when we can rely on validated, well-defined, high-priority military needs. DDR&E works with the Joint Staff J8 and Combatant Command (COCOM) Science Advisors to identify COCOM technology requirements and accelerate responsive technology into the acquisition process. The S&T Integrated Priority List (STIPL) ensures that COCOMs influence S&T program and resource decisions. In coordination with the Joint Staff, these STIPLs provide a critical input for determining overall Department technology needs to resolve approved COCOM capability shortfalls. While STIPLs may not reflect a complete list of COCOM technology needs, they are a key reference lens to focus the full force of the Defense S&T Team. After following this effort through its first cycle, I can tell you that this is an exciting and promising avenue to not only keep our warfighters on the cutting edge of technology but also reinvigorate the S&T community.

4. Agile Information Tools

Another improvement we have made for the Department is coordinating a free flowing exchange of ideas. Just as the warfighter requires new capabilities and tactics to meet the challenges of the 21st century battlefield, the DoD technology and acquisition communities need new tools to bring about strategic change in the DoD acquisition

process. Recognizing this need, and responding to needs articulated by of the USD (AT&L) and the DoD Chief Information Officer (CIO), the Defense Technical Information Center (DTIC) developed DoD Techipedia, a suite of services and processes that should speed technological innovation; increase awareness of new technologies across DoD; encourage collaboration and expand the pool of technology providers. The goal is to provide better capabilities to the warfighter faster and at less taxpayer expense through enhanced collaboration.

DoDTechipedia uses wiki, blog, and Web applications to bring together DoD researchers, technologists, and program managers. The DoDTechipedia Suite of Services currently has three interrelated components:

- DoDTechipedia Internal Wiki (https://www.DoDTechipedia.mil) is a collaborative wiki and blog application restricted to employees and contractors of the DoD and other Federal agencies. This wiki provides a living knowledge base that improves research awareness, reduces duplication of effort, and encourages Federal agency collaboration.
- DefenseSolutions.gov (http://defensesolutions.gov/) is a publicly available Web site aimed at non-traditional technology providers that have not done business with DoD in the past. The site encourages them to submit solutions to needs in selected technology areas.
- Defense Solutions is an information management system pilot project focused on streamlining the process for disseminating idea submissions to program managers' areas for evaluation.

Since October 2008, over 6,000 new users have registered for DoDTechipedia and have viewed more than 160,000 pages, participated in blogs, and added or edited almost 8,000 pages. DefenseSolutions.gov, which launched in February 2009 with a single technology area, has since received 44 proposed technology solutions, 14 undergoing further review and 6 being pursued. Usage and impact are expected to grow as marketing efforts increase awareness and DoD barriers to participating in social networking activities are addressed. By expanding collaboration, we also expect more scientists and engineers from "the digital generation" will be attracted to government service. By challenging the status quo within the defense community, DoDTechipedia is encouraging a more open and innovative capability development process.

Finally, we are examining how to extend the DoDTechipedia to a public site. There are policy issues to work through to include sensitivity/classification of an aggregated unclassified data. As we work through these issues, we hope to extend the site for greater application.

5. High Performance Computing

We can improve acquisition processes by expanding the use of common support tools. Our investments in science-based modeling and simulation through the HPCMP and Service-based computational science projects are paying off in major capability gains

and cost avoidance. In fact, we increased the investment in the DoD's High Performance Computing Modernization Program (HPCMP) in FY 2010.

A recent study documenting the impacts of all HPCMP investments shows a return on investment of better than 6 to 1. Improvement in the accuracy of our ocean simulations will soon provide our submarine commanders with near-real time knowledge of the impact of the ocean conditions on the performance of their sonar, allowing much greater situational awareness. The use of science-based models and supercomputers improved armor designs for faster delivery to our ground forces. Much of the recently deployed armor improvements in use today in Iraq and Afghanistan benefited from these high-end simulations. Our process for certifying the airworthiness of different combinations of stores (bombs, external fuel tanks, missiles, and pods) that hang on fighter aircraft has been fundamentally transformed through the use of HPCMP assets. Today, science-based simulations form the core of this critical process are used throughout DoD to assure the flight safety of different store combinations on different combat aircraft. Multiple stores combinations have been approved and used in Iraq and Afghanistan, and were approved much more quickly and safely than previously possible, using high quality models running on the high performance computers.

In FY 2009, we embarked on a new effort called Computational Research and Engineering for Acquisition Tools and Environments (CREATE) program which aims at transitioning supercomputer models and simulations, commonly used in the research community, into tools that can be routinely used by the systems development or acquisition community. The CREATE program, an element of the HPCMP is working to replace the existing DoD design paradigm for major systems that rely on extrapolation of historical data and experimental testing with a new paradigm that exploits science-based computational tools. Developing and deploying tools through CREATE should be an important step needed to improve our acquisition processes. Our engineering community needs modern tools they can use to make better, less risky choices earlier in the design process. Many industries and government agencies - Goodyear Tire, Whirlpool, and the US nuclear weapons design program - are replacing or have replaced their experimentally-based development methodologies with newer modern systems and engineering approaches. These modern approaches are based on the iterated use of computational engineering tools applied in "design-mesh analyze" cycles that lead to building and testing the end product, enabling industries and government agencies to produce and deliver better products much more quickly and less expensively. The Department needs to do the same. The CREATE program is building science-based models and simulation tools focused on supporting the development of ships, air vehicles, and radio frequency antennas (integrated with platforms). CREATE is a long-term investment that will initially integrate and upgrade existing science-based research tools to make them more appropriate for engineering applications. In the long run, CREATE will introduce highly scalable, coupled multi-physics software applications that will exploit next generation supercomputers and future high-end workstations.

6. DoD Manufacturing S&T Program

Other, more traditional, S&T programs continue to lower risk in all phases of acquisition. The Department's ManTech Program facilitates technology transition through significant reductions in cost and cycle time, increased reliability, and increased return on investment.

In FY 2009, we increased the defense-wide ManTech S&T investment which has a long history of lowering risk in all phases of our acquisition programs, and serves as a link between technology inventions and industrial applications giving the program a unique position within the defense industrial base and broader strategic security environment. Further, the GAO has concluded in successive annual weapon system reviews, that entering production with immature manufacturing capabilities, like entering development with immature technology, is a significant contributing factor to cost and schedule overruns.

The ManTech Program's core focus on closing manufacturing technology capability gaps and reducing risk is therefore an important part of the Department's solution to its growing affordability and acquisition timeline challenges. Identifying production issues early and providing timely solutions, the ManTech Program reduces risk and positively impacts system affordability by providing solutions to manufacturing problems before they occur. A few recent examples will help illustrate.

- The Army ManTech Program improved fabrication processes, explosive loading technologies, and developed an affordable and repeatable assembly method resulting in $33M cost avoidance and MEMS S&A use in precision-guided artillery.

- The Navy has a goal to ensure that the VIRGINIA Class Submarine (VCS) program is affordable; the cost to build one submarine must be less than $2B and must be completed in less than 84 months. Navy ManTech is currently investing in over 60 projects focused on cost reductions to support the VIRGINIA Class Submarine affordability goals. A recent example of the Navy ManTech investment and its significance to the VCS is the adaptation of the Laser Projection System, an image projection technology for locating attachments and penetrations on the interior hull of the submarine, previously a labor-intensive process using paper templates and manual measurements. VCS is saving nearly 8,000 labor hours per ship for electrical, heating/ventilation/air conditioning and stud installs.

- The Army ManTech Uncooled Focal Plane Array Producibility Manufacturing Technology Objective improved producibility of the high resolution, uncooled IR sensor technology in order to affordably field advanced uncooled IR sensor technology to meet Future Combat System requirements. High sensitivity, high-resolution (640x480), uncooled infrared (UCIR) sensors are too expensive for the sensors to widely proliferate throughout Army systems. Additionally, there is a

very large mismatch between production capacity and current and future force projected requirements (>12,000 packaged UCIR FPAs per year). Measured yields have improved from less than 10% to over 50% and cost is reduced from $16K to $2K per focal plane array, enabling proliferation of new, affordable sensor technology.

DMEA

Finally, in FY 2009, DDR&E assumed responsibility for the Defense Microelectronics Activity (DMEA). The DMEA provides a vital service as the joint DOD center for microelectronics acquisition, transformation, and support; advancing future microelectronics research, development, technologies, and applications to achieve DOD's strategic and national security objectives.

DMEA applies advanced technologies to create or add performance enhancements in response to the newest Irregular Warfare threats and to modernize aging weapon systems. Program Managers use DMEA for assistance with resolving microelectronics technology issues in weapons systems. DMEA quickly presents them with appropriate solution options to not only keep a system operational but also elevate it to the next level of sophistication or to meet new threats.

DMEA employs in-house engineering capability to rapidly design, develop, and demonstrate microelectronics concepts, advanced technologies, and applications horizontally throughout the DOD. The contractor capabilities are primarily obtained through the Advanced Technology Support Program (ATSP), an Indefinite Delivery/Indefinite Quantity (IDIQ) contract with a $4.7 Billion ceiling. In a matter of weeks, ATSP provides government organizations streamlined access to commercial state-of-the-art technologies and engineering capability through leading defense industry resources within a fully competitive environment. DMEA provides essential systems and specialized government engineering oversight when contractors are used. DMEA and the ATSP contract can be utilized to provide the warfighter with improved operational readiness, new capabilities, and dramatically enhanced performance through the application of advanced technologies and sophisticated engineering techniques.

DMEA has developed the in-house one-of-a-kind Advanced Reconfigurable Manufacturing for Semiconductors (ARMS) foundry to produce specialized microelectronic devices, such as Application Specific Integrated Circuits. The ARMS can be "flexed" on demand to fabricate integrated circuit (IC) devices on multiple commercial manufacturing processes with different feature sizes and technologies. This flexibility satisfies the DMEA mission to provide microelectronics solutions, and results in a "just enough, just in time" ability to provide analog, digital and mixed signal integrated circuits, hybrid and multi-chip module products. In support of DODI 5200.39 - Critical Program Information (CPI) requirements, DMEA can provide trusted products from our in-house capability. DMEA is also accrediting all parts of the commercial

trusted supply chain (e.g., design, aggregator/broker, mask and wafer fabrication, packaging and test services) to allow acquisition of CPI trusted products in a variety of process technologies and geometry node-sizes for specialized government applications, both classified and unclassified. Over the past 20 years, DMEA has supported the DOD and federal organizations with thousands of tasks using a highly streamlined competitive acquisition process resulting in over $5.5B in cost avoidance.

Summary

In conclusion, the DoD S&T community has adapted and will continue to adapt to the needs of the warfighter as guided by the four strategic principles laid down by Secretary Gates. The basic research portfolio is expanding to meet President Obama's challenge of leading worldwide S&T efforts and Secretary Gates' direction. DoD S&T investments have been tailored to the Irregular Warfare fight in which we now find ourselves. By expanding our S&T program to better take care of our people, to develop capabilities both for the current fight and any future conflicts, as well as working on specific S&T issues to improve our Department's acquisition process, the S&T community stands ready to provide combatant commanders the tools necessary to carry out their respective missions around the world. Our measure of success will always be the ability for our soldiers, sailors, airmen and marines to maintain a technological advantage on the battlefield to ultimately prevail in combat. We appreciate the opportunity to provide this update on the status of the DoD S&T enterprise to the committee, and the privilege to support our warfighters.